U.S. General Services Administration

# Ambulance Technology and Standards Update Part I

James D. Green
National Institute for Occupational Safety and Health (NIOSH)

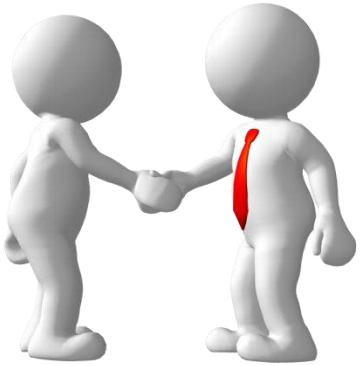
**2015 Federal Fleet Management Training**
General Services Administration

# GSA Motor Vehicle Management Value Proposition



Right Vehicle

Right Price



Great Service

*and the required data needed to effectively and efficiently manage a fleet*

# Ambulance Design - Then

# Ambulance Design - Now

# Why do we seek opportunities for improvement?

Prior to crash equipment and gurney either mounted or stowed in cabinets


Post crash (rollover) equipment and gurney positions drastically changed

# Background & Participants

**Bringing the right expertise to address the problems to be solved:**

**Improving Occupant Safety**

# Overarching Goals of this Research

- Provide patient compartment occupants with the same level of crash protection as passenger vehicles
- Work with end users to ensure designs meet needs
- Near Term: Develop system specific test methods for publication to be referenced nationally or internationally
- Long Term: Incorporate changes into one or more bumper-to-bumper ambulance national standards

***** Most Importantly - Ensure all proposed test methods are based on actual test data *****

# Industry Partners

- National Truck Equipment Association's Ambulance Manufacturer's Division
  - Represents 20 ambulance builders
  - Over 90% of US ambulances are manufactured by AMD members
- Patient Litter Manufacturers – 100% of the US market
  - Stryker Medical
  - Ferno Washington
- Seating Manufacturers – over 90% of all EMS seating
  - EVS Limited
  - Wise Seating
  - Serenity Safety Products

# Automotive Testing Expertise Applied

- Testing performed by three private companies at five different crash test facilities from Wisconsin to Virginia
  - Center for Advanced Product Evaluation (CAPE)
  - MGA Research
  - Transportation Research Center
- National Highway Traffic Safety Administration's
    - Vehicle Research Test Center, East Liberty, Ohio
    - Office of Vehicle Crashworthiness Research, Washington, DC
- General Services Administration
- Federal Aviation Administration

# Crash Standard Development

## Vehicle Response Provides Foundation for Future Work

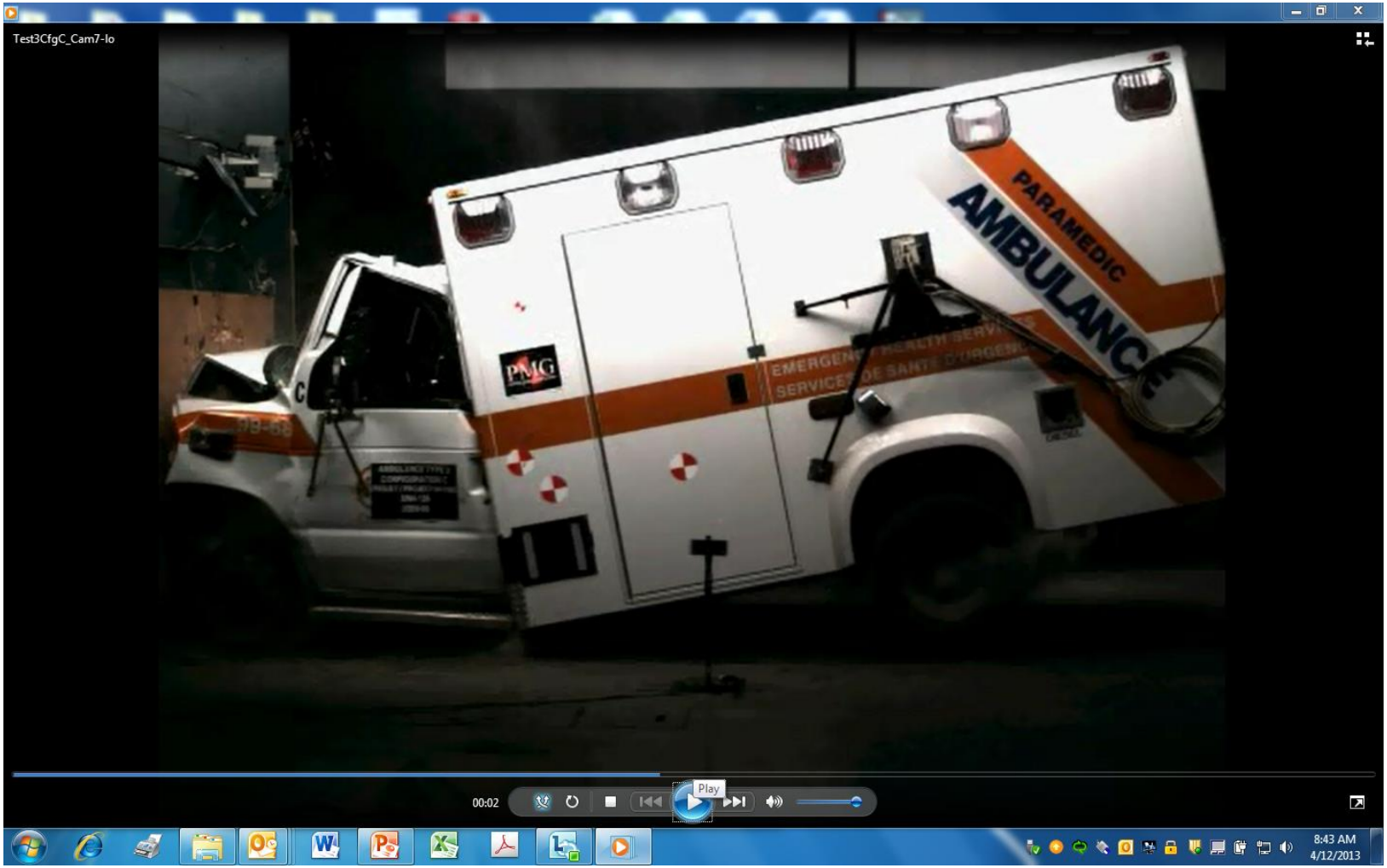
# What Impact Load Should We Use?

≈ 30 mph – likely survivable

≈ 60 mph – likely not survivable

"Ride of your Life: What you Can't Afford Not to Know About Ambulance Safety", Levick, N. Presented at TSJC/RETAC EMS Symposium "Making A Difference" February 11, 2012, Alamosa, Colorado

# Conducted 3 Frontal Impact Tests: 30 MPH Into Barrier



# Conducted 4 Side Impact Tests at 30 MPH Using a 3,3300 lb. MDB

# Test Load Criteria – Frontal & Side Impact

SAE International | SURFACE VEHICLE RECOMMENDED PRACTICE | SAE J2917 MAY2010 | Issued 2010-05

Occupant Restraint and Equipment Mounting Integrity – Frontal Impact System-Level Ambulance Patient Compartment

SAE J2917 Issued MAY2010 Page 3 of 4

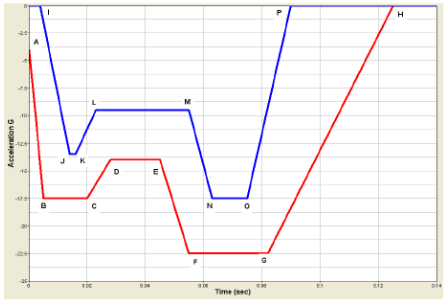



FIGURE 1 - DYNAMIC SLED CORRIDOR

TABLE 1 - DYNAMIC SLED CORRIDOR BREAK POINTS

| Position | Time (sec) | Acceleration (g) |
|---|---|---|
| A | 0.000 | -4.0 |
| B | 0.005 | -17.5 |
| C | 0.020 | -17.5 |
| D | 0.028 | -14.0 |
| E | 0.045 | -14.0 |
| F | 0.055 | -22.5 |
| G | 0.082 | -22.5 |
| H | 0.125 | 0.0 |

| Position | Time (sec) | Acceleration (g) |
|---|---|---|
| I | 0.004 | 0.0 |
| J | 0.014 | -13.5 |
| K | 0.016 | -13.5 |
| L | 0.023 | -9.5 |
| M | 0.055 | -9.5 |
| N | 0.063 | -17.5 |
| O | 0.075 | -17.5 |
| P | 0.090 | 0.0 |

**SAE J2917- Ambulance Patient Compartment Frontal HYGE Sled Pulse, May 2010**

SAE International | SURFACE VEHICLE RECOMMENDED PRACTICE | SAE J2956 JUN2011 | Issued 2011-06



SAE J2956 Issued JUN2011 Page 3 of 4

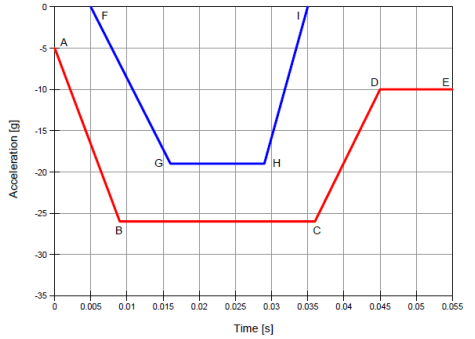



FIGURE 1 - DYNAMIC SLED CORRIDOR

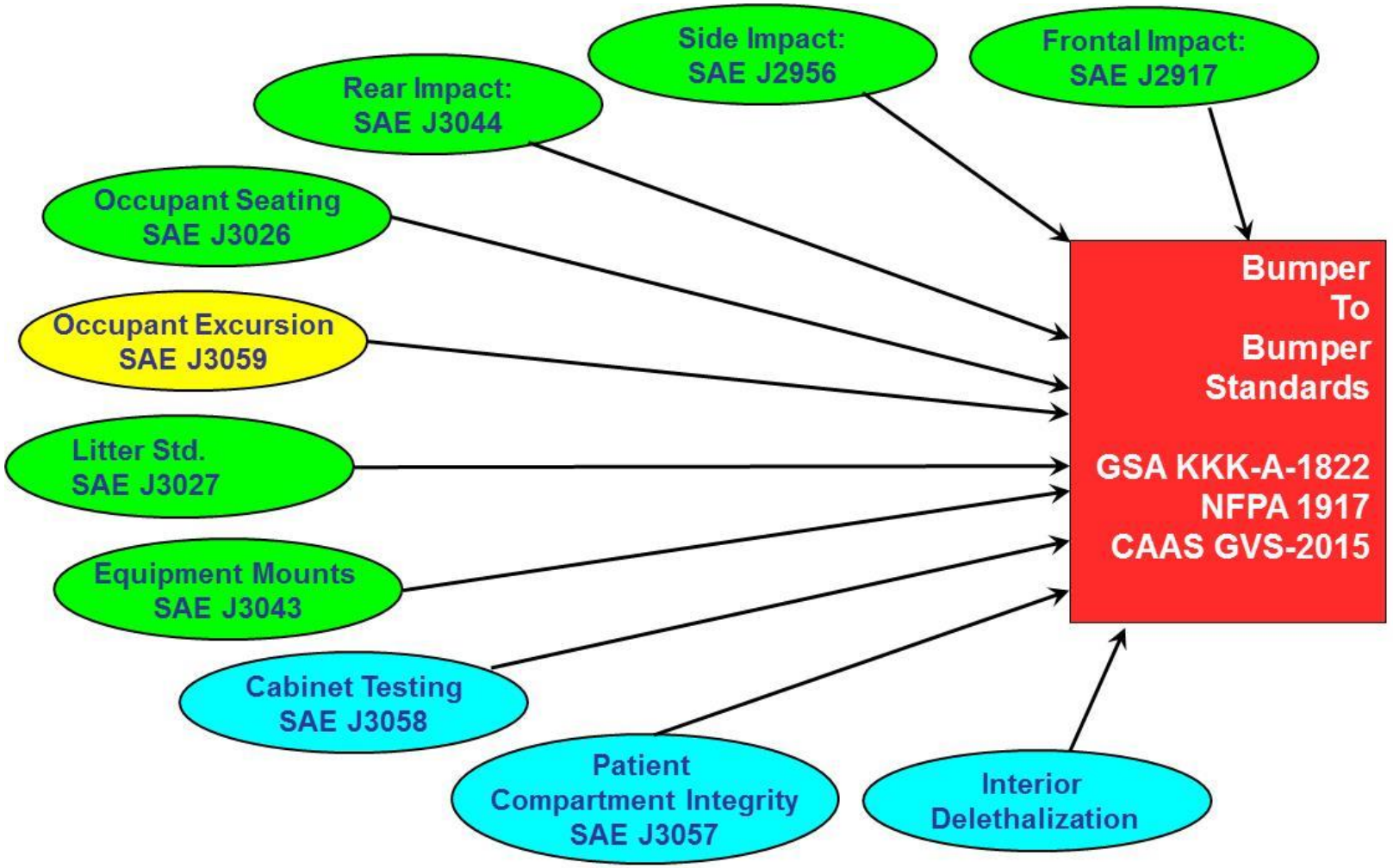
TABLE 1 - DYNAMIC SLED CORRIDOR BREAK POINTS

| Position | Time (sec) | Acceleration (g) |
|---|---|---|
| A | 0 | -5.0 |
| B | 0.009 | -26.0 |
| C | 0.036 | -26.0 |
| D | 0.045 | -10.0 |
| E | 0.055 | -10.0 |

| Position | Time (sec) | Acceleration (g) |
|---|---|---|
| F | 0.005 | 0.0 |
| G | 0.016 | -19.0 |
| H | 0.029 | -19.0 |
| I | 0.035 | 0.0 |

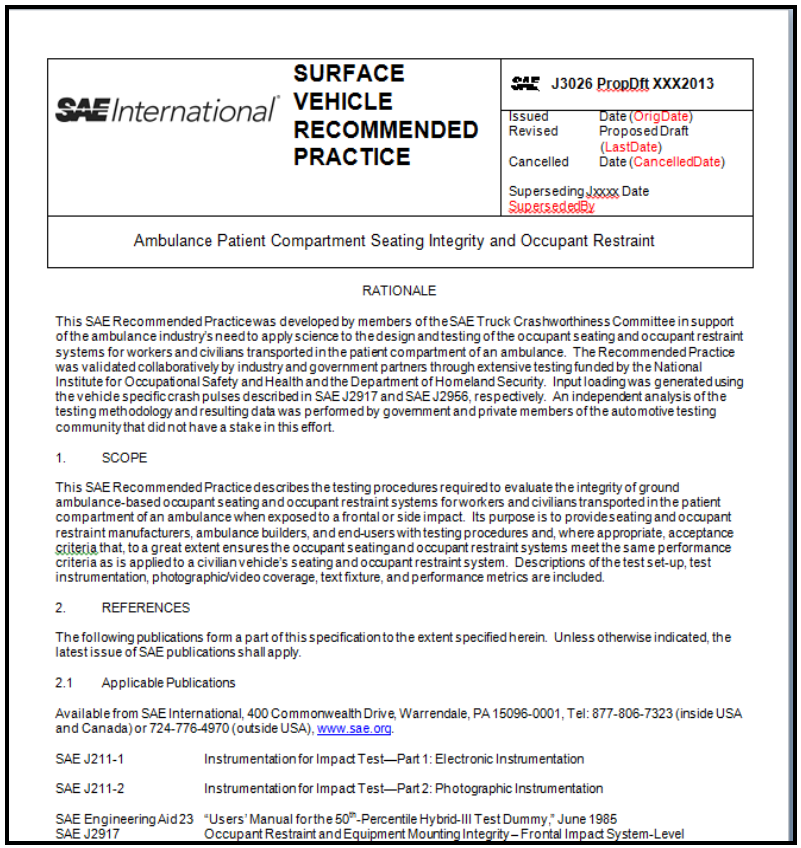
**SAE J2956- Ambulance Patient Compartment Lateral HYGE Sled Pulse, June 2011**

# Standards Landscape Tomorrow



# Seat and Worker Restraint: Test Methodology

## SAE J3026 Published in August 2014



SAE International

**SURFACE VEHICLE RECOMMENDED PRACTICE**

SAE J3026 PropDft XXX2013

Issued Date (OrigDate)
Revised Proposed Draft (LastDate)
Cancelled Date (CancelledDate)

Superseding Jxxxx Date SupersededBy

Ambulance Patient Compartment Seating Integrity and Occupant Restraint

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the occupant seating and occupant restraint systems for workers and civilians transported in the patient compartment of an ambulance. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health and the Department of Homeland Security. Input loading was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community that did not have a stake in this effort.

1. SCOPE

This SAE Recommended Practice describes the testing procedures required to evaluate the integrity of ground ambulance-based occupant seating and occupant restraint systems for workers and civilians transported in the patient compartment of an ambulance when exposed to a frontal or side impact. Its purpose is to provide seating and occupant restraint manufacturers, ambulance builders, and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent ensures the occupant seating and occupant restraint systems meet the same performance criteria as is applied to a civilian vehicle's seating and occupant restraint system. Descriptions of the test set-up, test instrumentation, photographic/video coverage, text fixture, and performance metrics are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

SAE J211-2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation

SAE Engineering Aid 23 "Users' Manual for the 50th-Percentile Hybrid-III Test Dummy," June 1985
SAE J2917 Occupant Restraint and Equipment Mounting Integrity – Frontal Impact System-Level

### Key Elements in this Recommended Practice

- Dynamic, crash testing is required
- Seat and restraint systems must protect occupants to same crash standard as automotive seating
- Loading to the crash test dummy must fall below automotive test limits

# Frontal Impact, Forward and Rear Facing Seating

# Mapping Occupant Excursion

## SAE J3059 Submitted for Review and Approval

SAE International

**SURFACE VEHICLE RECOMMENDED PRACTICE**

~~SAE~~J3059 PropDft Aug 28, 2014

Issued Date (OrigDate)

Ambulance Patient Compartment Seated Occupant Excursion Zone Evaluation

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the occupant seating and occupant restraint systems for workers and civilians transported in the patient compartment of an ambulance. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health, the Department of Homeland Security and the Ambulance Manufacturers Division of the NTEA. Input loading was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community.

1. SCOPE

This SAE Recommended Practice describes the testing and reporting procedures that may be used to evaluate and document the excursion of a worker or civilian when transported in a seated and restrained position in the patient compartment of a ground ambulance when exposed to a frontal or side impact. Its purpose is to provide seating and occupant restraint manufacturers, ambulance builders, and end-users with testing procedures and documentation methods needed to identify ~~potential head impact locations and/or~~ head travel paths in crash loading events. This is a component level test. The seating system is tested in free space to measure maximum head travel paths. The purpose is not to develop stay out zones. Rather, the goal is to provide ambulance manufacturers with the data needed to design safer and functionally sound work stations for Emergency Medical Service workers so that workers are better able to safely perform patient care tasks in a moving ambulance. Descriptions of the test set-up, test instrumentation, photographic/video coverage, text fixture, and reporting requirements are included.

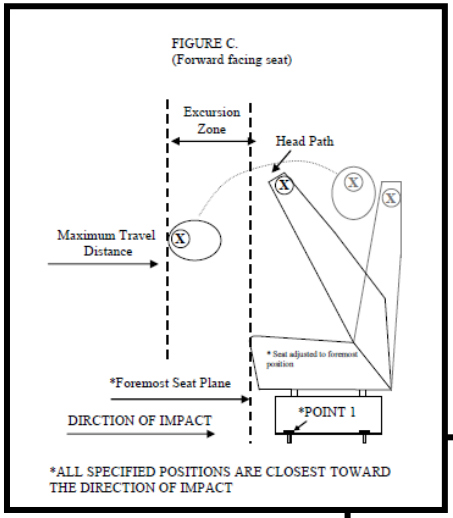
2. REFERENCES

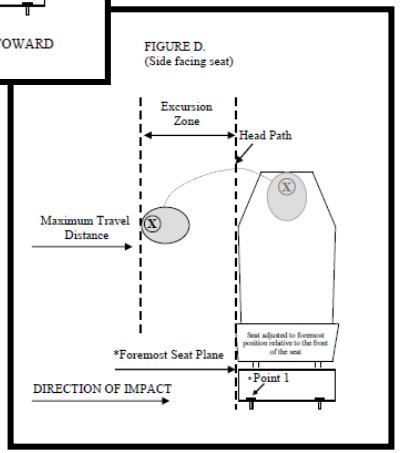
The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation



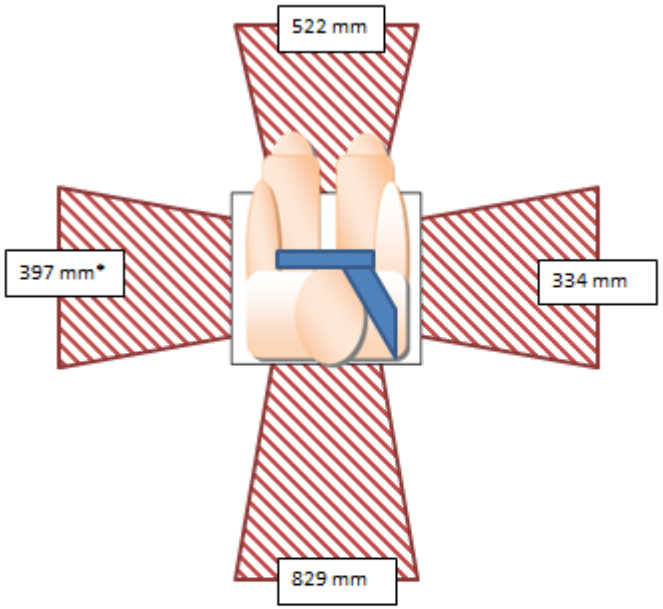
# Seating and Restraint Data Sheet

**Seat Model #1 Stay-Away-Zone**

Units are in millimeters. Drawings are not to scale.

Measurements are from the *foremost seat plane* in each direction.

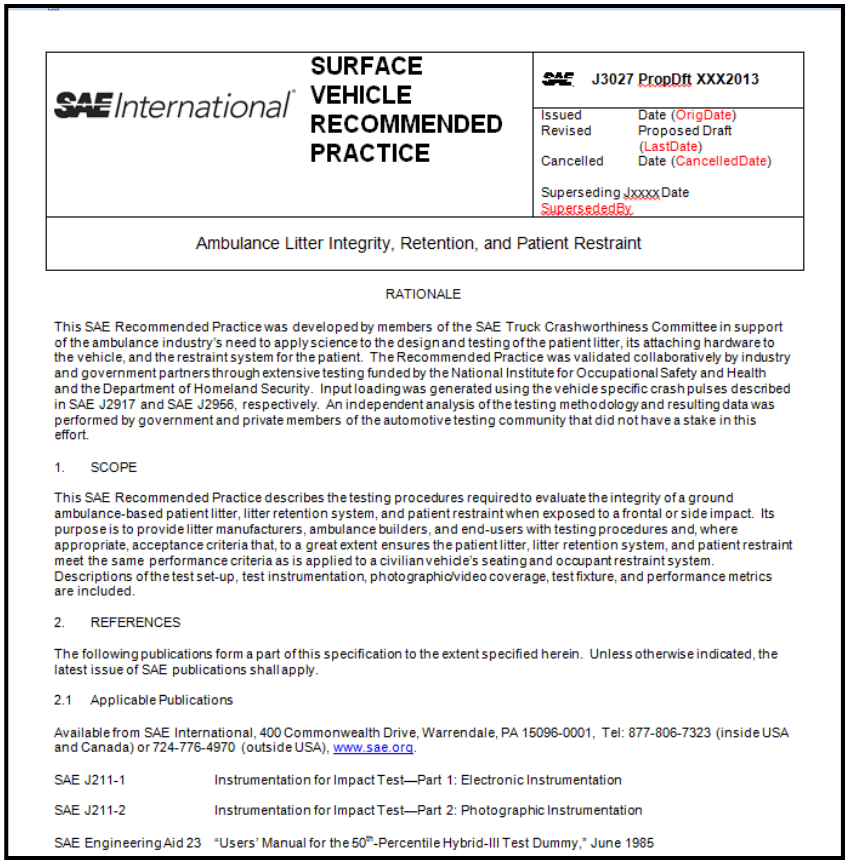
*Side impact pulse data




| Seat Attitude | Pulse | Max Excursion (mm) | Peak Velocity (m/s) | Excursion @ Peak Vel (mm) | Vel @ 0mm (m/s) | Vel @ 50mm (m/s) | Vel @ 100mm (m/s) | Vel @ 150mm (m/s) | Vel @ 200mm (m/s) | Vel @ 250mm (m/s) | Vel @ 300mm (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fwd | J2917 | 522 | 11.3 | 380 | 6.8 | 7.9 | 8.8 | 9.5 | 10.0 | 10.0 | 10.8 |
| Side | J2917 | 334 | 13.4 | 189 | 9.6 | 10.3 | 11.1 | 12.2 | 13.1 | 11.8 | 12.5 |
| Rear | J2917 | 829 | 15.7 | 309 | 9.9 | 11.1 | 11.1 | 12.8 | 13.3 | 14.1 | 15.3 |
| Side | J2956 | 397 | 8.8 | 16 | 8.5 | 8.5 | 8.3 | 8.4 | 8.5 | 8.2 | 8.6 |

# Patient Cot and Restraint: Test Methodology

SAE J3027 Published in July 2014



SAE International

**SURFACE VEHICLE RECOMMENDED PRACTICE**

SAE J3027 PropDft XXX2013

Issued Date (OrigDate)
Revised Proposed Draft (LastDate)
Cancelled Date (CancelledDate)

Superseding Jxxxx Date SupersededBy

Ambulance Litter Integrity, Retention, and Patient Restraint

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the patient litter, its attaching hardware to the vehicle, and the restraint system for the patient. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health and the Department of Homeland Security. Input loading was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community that did not have a stake in this effort.

1. SCOPE

This SAE Recommended Practice describes the testing procedures required to evaluate the integrity of a ground ambulance-based patient litter, litter retention system, and patient restraint when exposed to a frontal or side impact. Its purpose is to provide litter manufacturers, ambulance builders, and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent ensures the patient litter, litter retention system, and patient restraint meet the same performance criteria as is applied to a civilian vehicle's seating and occupant restraint system. Descriptions of the test set-up, test instrumentation, photographic/video coverage, test fixture, and performance metrics are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

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SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

SAE J211-2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation

SAE Engineering Aid 23 "Users' Manual for the 50th-Percentile Hybrid-III Test Dummy," June 1985

## Key Elements in Recommended Practice

- Dynamic, crash testing is required
- Cot, cot mounting and restraints structurally sound during simulated crash loading
- Occupant excursion reduced to less than 14 inches

# Standard Litter – 30 mph Barrier Impact

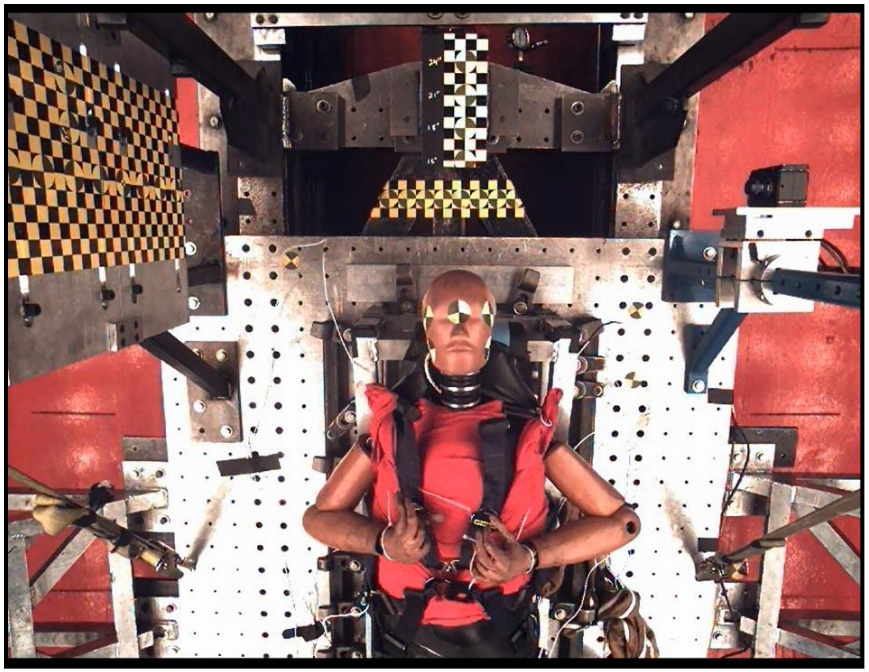
**Pre-crash event: standard litter, restraint and antler floor fastener**

**Worker in rear-facing seat**

**Mid-crash event: patient excursion exceeds 30 inches or 76 cm**

**Worker impacted by patient**

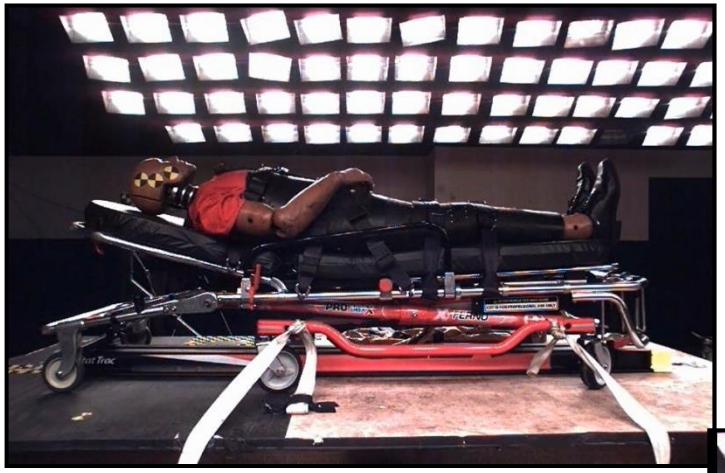
# Rigid Litter With New Restraint Tested Using J2917



**Pre-crash event: rigid litter, new restraint applied directly to shoulder**

**Mid-crash event: total head excursion of 7.8 in / 20 cm**

# 30 MPH Sled Test – Production Litter (SAE J2917)



**Production litter with new patient restraint and floor mount system**

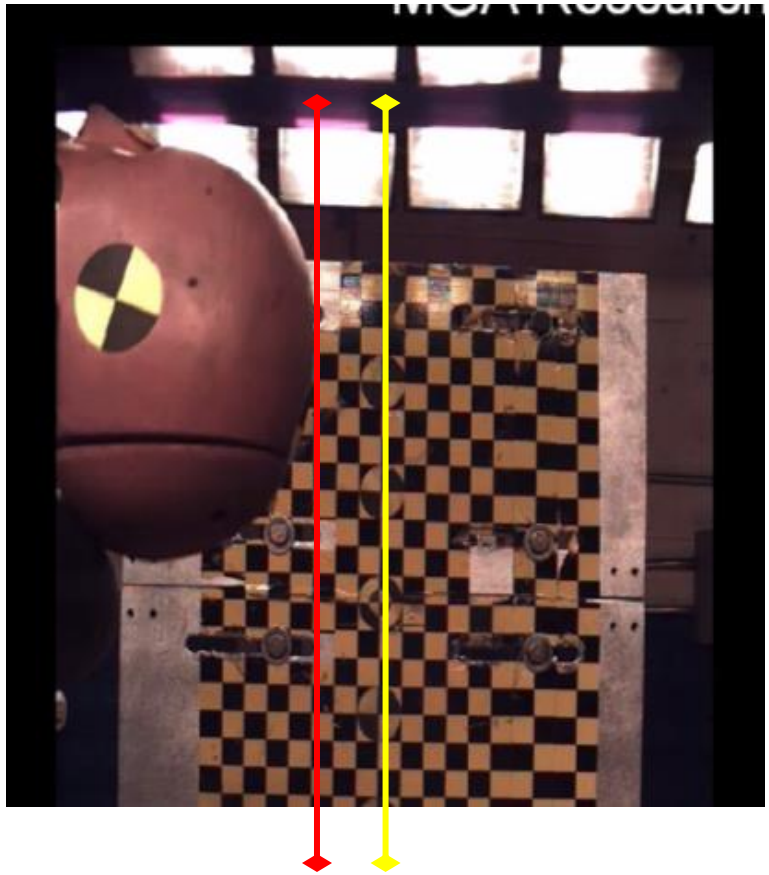

**Production litter: Occupant excursion falls below maximum limit of 14 inches even when including excursion associated with litter frame deflection**

# Patient Litter & Restraint: Patient Excursion

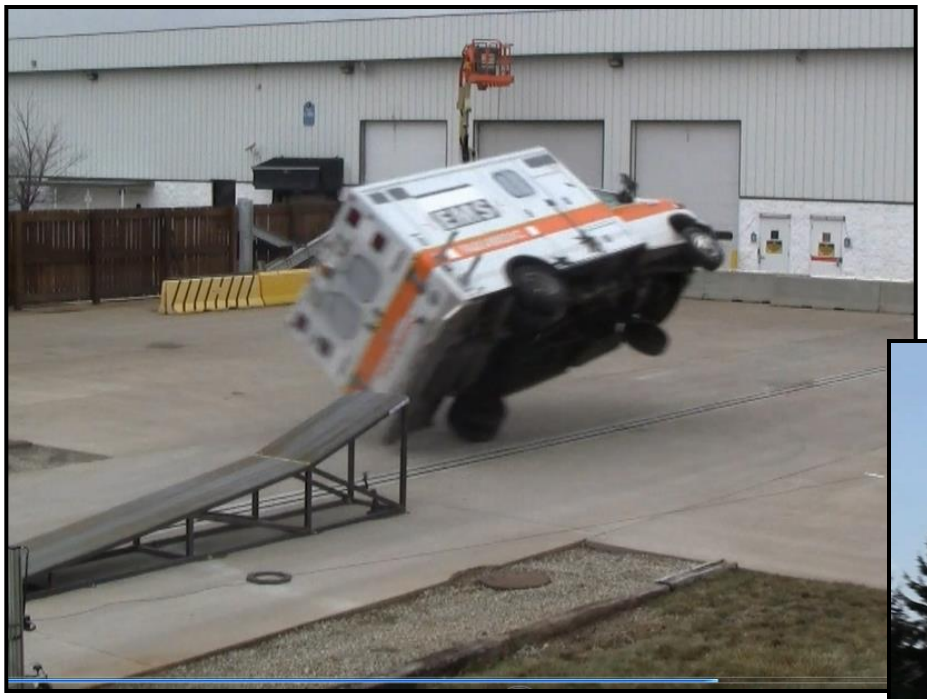
(14 inch Maximum Excursion Limit – The Goal Line View)

**Production litter, litter floor fixture, and occupant restraint – max excursion 11" This test meets the new standard**

**** Manufacture not identified due to confidentiality agreement**



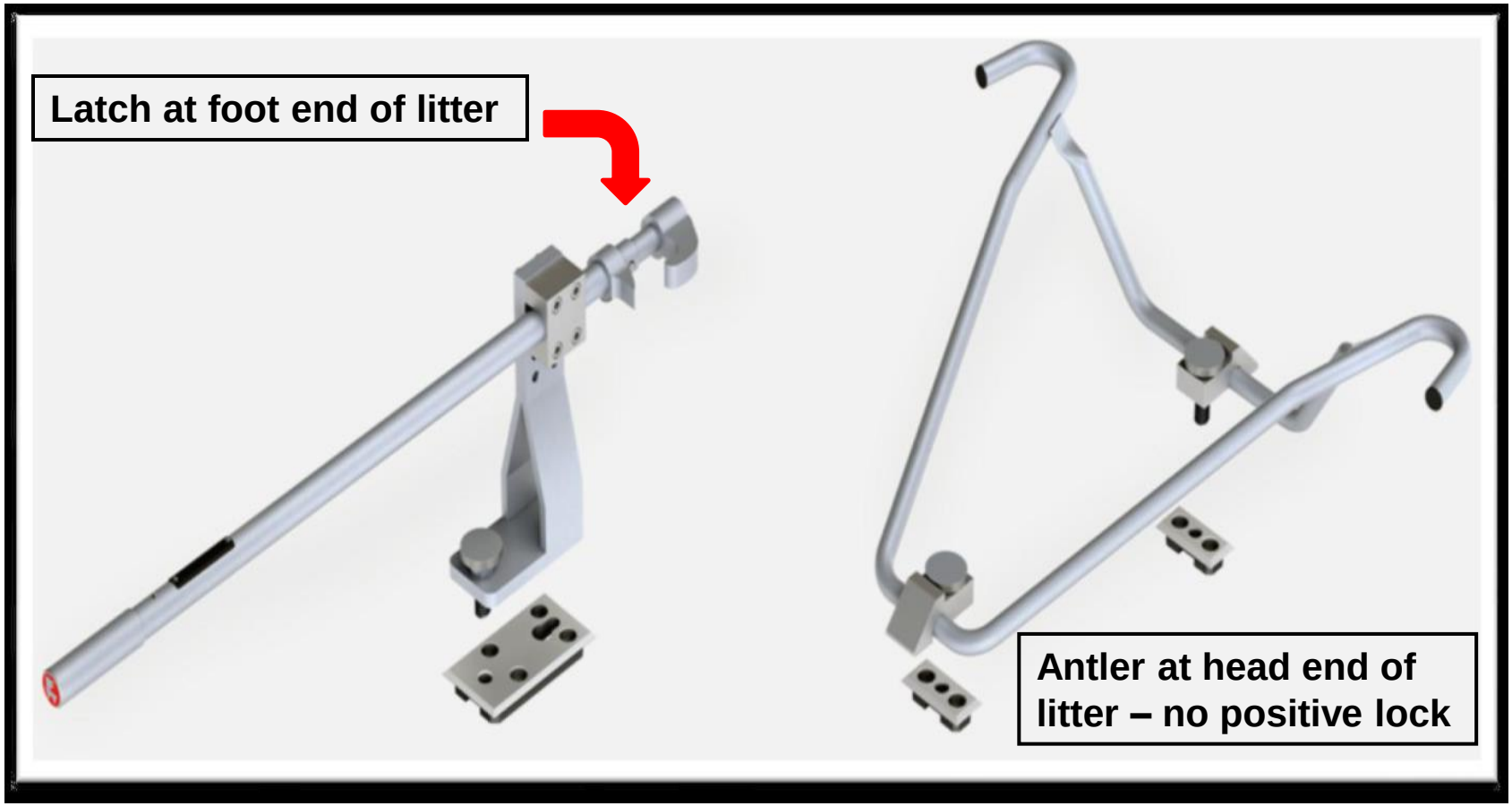
# Ramp and Cart Roll Tests with Cots: 30 MPH



**A new prototype litter and instrumented crash test dummy installed in each ambulance – one from Stryker and one from Ferno**

**Both litters and their floor fixtures remained structurally sound, with the patient securely restrained. Dummy parameters fell below NHTSA limits**

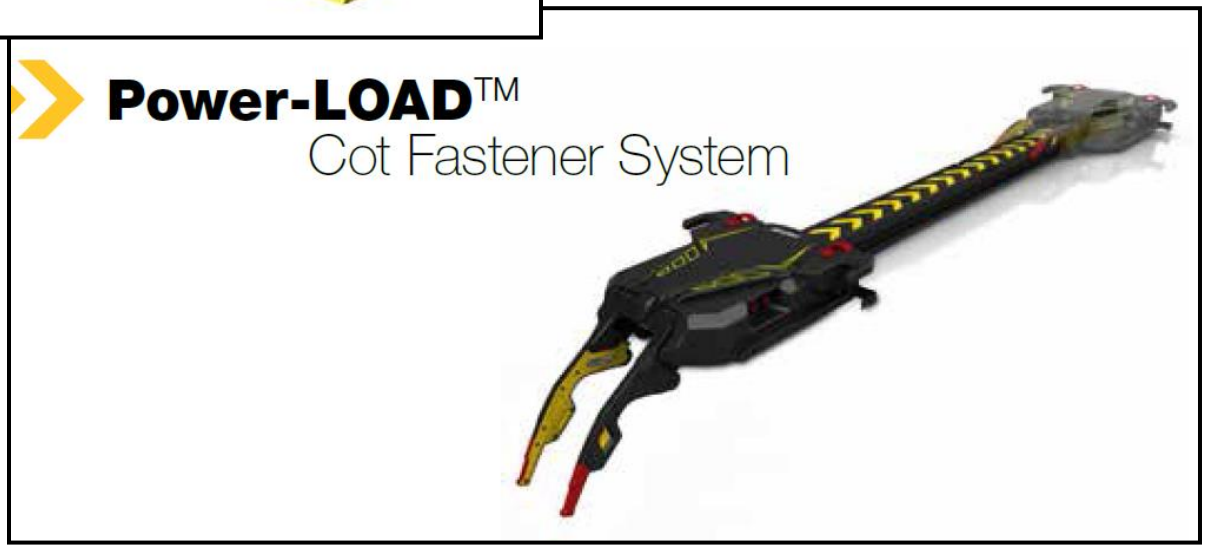
# Traditional Standard Litter or Cot Floor Fixture




**This system was designed to attenuate only 2,200 lbs. of loading**

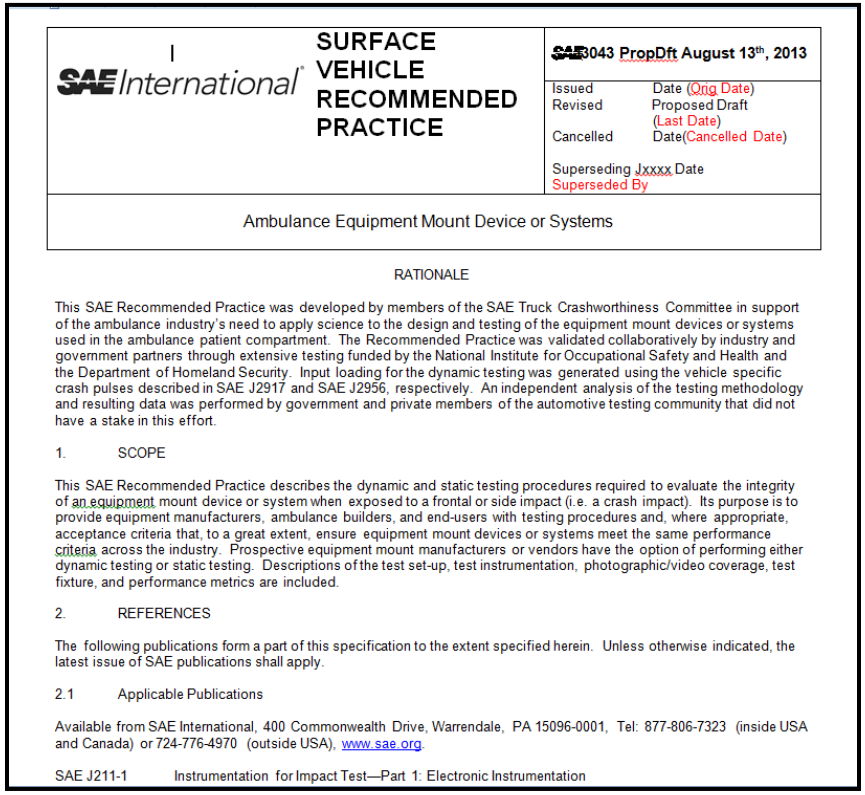
# Ambulance Design - Now


New Litter Floor Mount Systems Have robust, Positive Locking Mechanisms



# Equipment Mounting: Test Methodology

SAE J3043 Published in July 2014



SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J3043 PropDft August 13th, 2013

Issued Date (Orig Date)
Revised Proposed Draft (Last Date)
Cancelled Date(Cancelled Date)

Superseding Jxxxx Date
Superseded By

Ambulance Equipment Mount Device or Systems

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the equipment mount devices or systems used in the ambulance patient compartment. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health and the Department of Homeland Security. Input loading for the dynamic testing was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community that did not have a stake in this effort.

1. SCOPE

This SAE Recommended Practice describes the dynamic and static testing procedures required to evaluate the integrity of an equipment mount device or system when exposed to a frontal or side impact (i.e. a crash impact). Its purpose is to provide equipment manufacturers, ambulance builders, and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent, ensure equipment mount devices or systems meet the same performance criteria across the industry. Prospective equipment mount manufacturers or vendors have the option of performing either dynamic testing or static testing. Descriptions of the test set-up, test instrumentation, photographic/video coverage, test fixture, and performance metrics are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

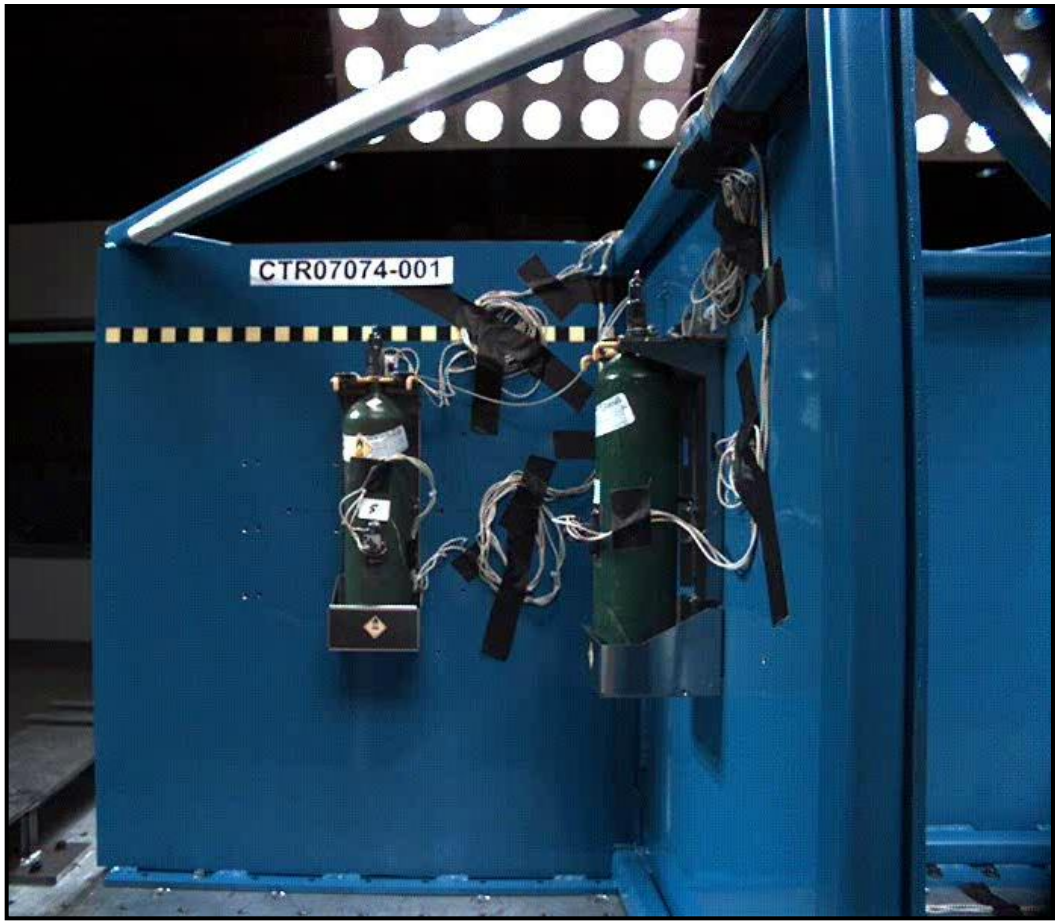
## Key Elements in Recommended Practice

- Dynamic testing based on published pulses is an option
- Static test in lieu of dynamic test is also an option
- Innovative conversion from dynamic to static test loading offered

# Equipment Mounting: Dynamic Test Option

Dynamic Test

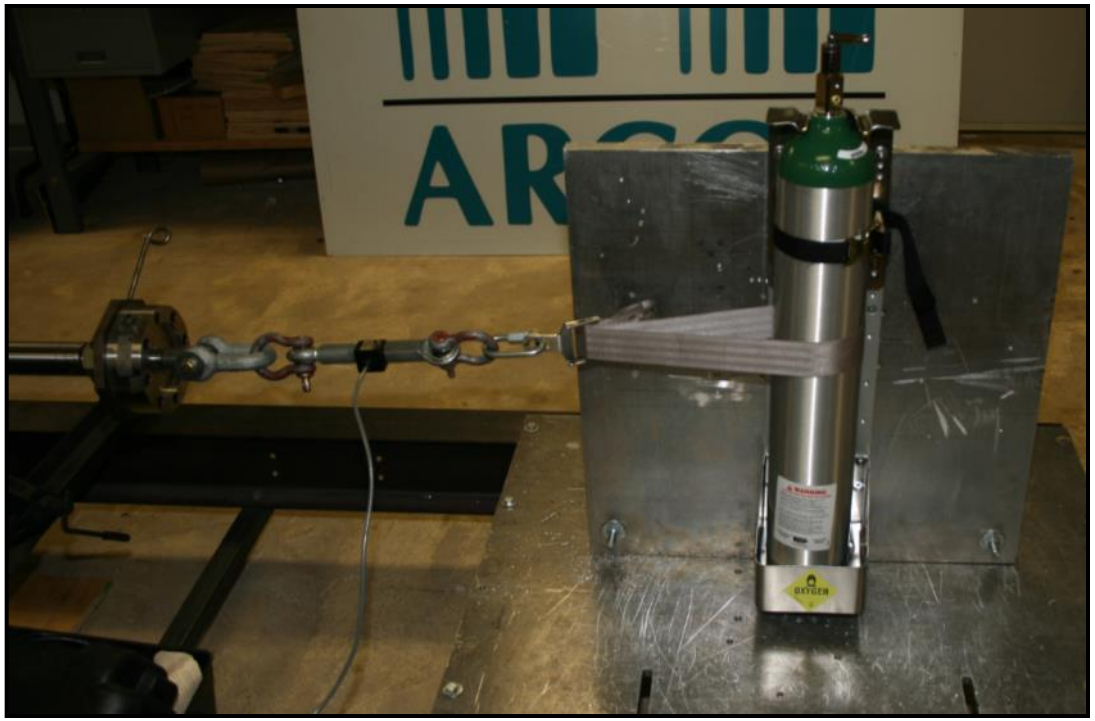
- Simulates crash loading directly
- Utilizes front and side crash pulses from SAE J2917 and SAE J2956
- Equipment must be retained in mount throughout the test



# Equipment Mounting: Static Test Option

Static Test

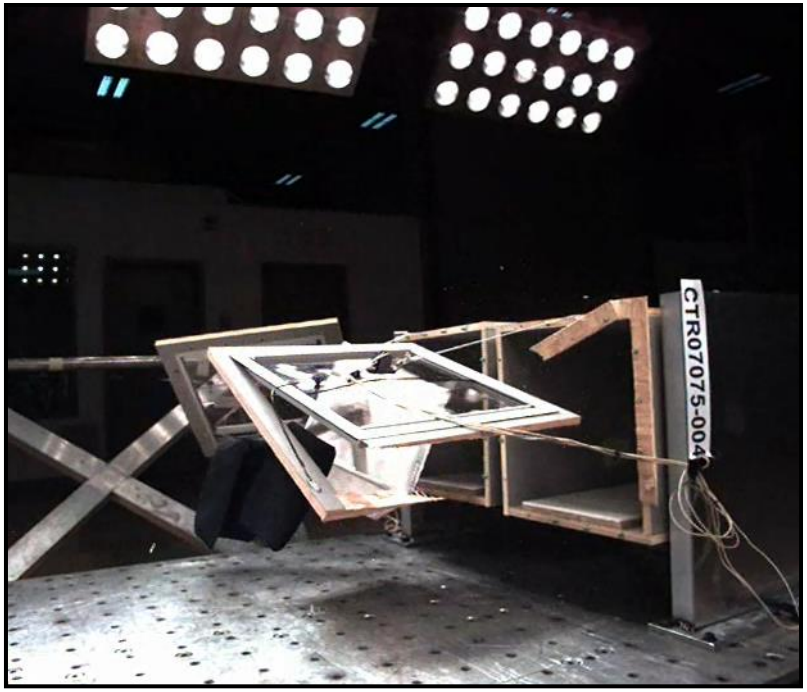
- Is a simple, one axis pull test
- Estimated loading increased by 50%
- Should be performed in multiple axis; one pull at a time



Static Load = Peak G x Weight x 1.5 amp factor
Example: (10 lb. O2 Cylinder. Tested for 22.5 G frontal impact requires a pull test of: 10 x 22.5 x 1.5 = 340 lbs.

# Cabinet Closure & Retention: Test Methodology

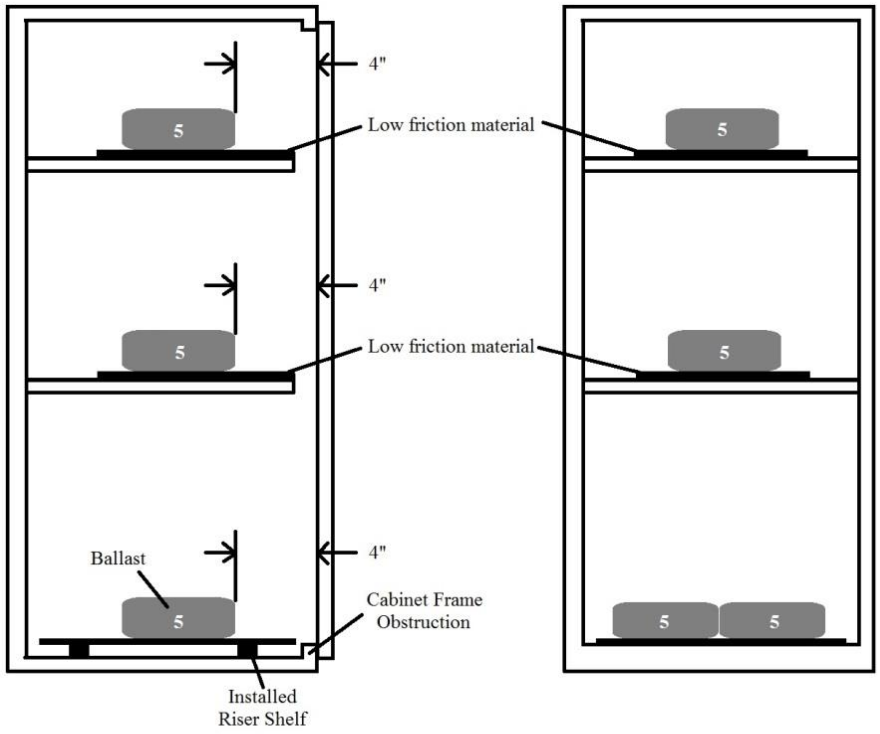
SAE J3058 Will be submitted for publication summer 2015



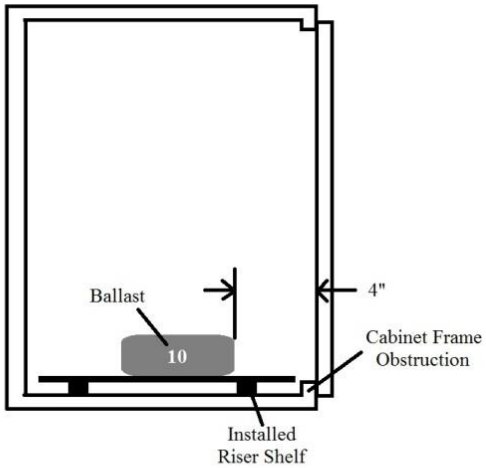

Key Elements in Recommended Practice

- Dynamic testing based on published crash pulses
- Cabinet is to have a weight rating – rated by manufacturer
- Cabinet must stay closed to retain contents
- Cabinet must remain attached to simulated wall surface

# Cabinet Closure & Retention: Test Methodology



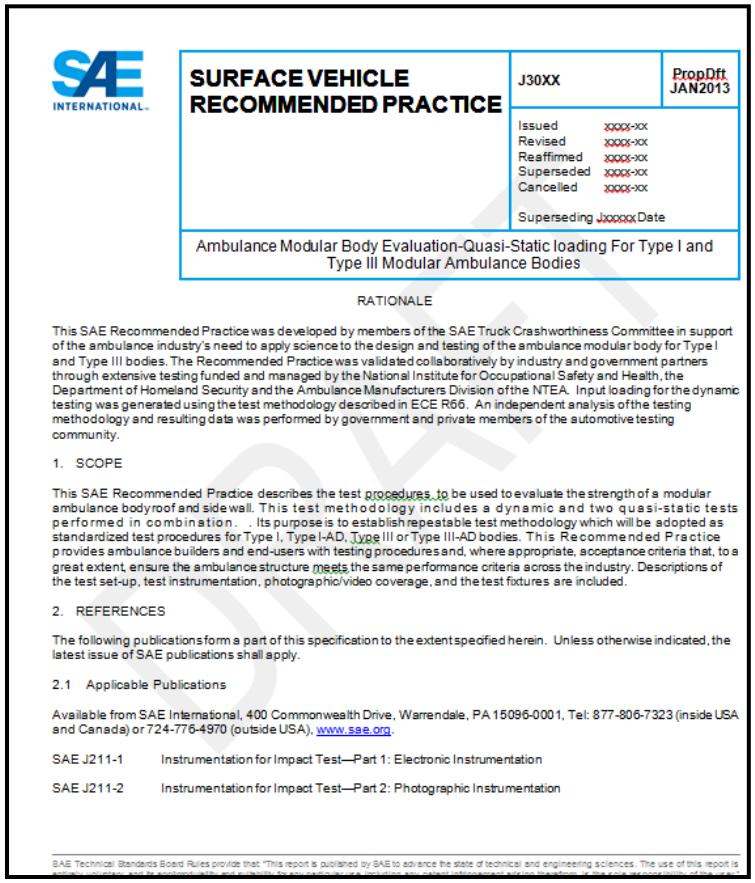

Multiple Shelf Cabinet




Single Cabinet

# Modular Body Structural Integrity: Test Methodology

SAE J3058 Will be submitted for publication summer 2015



SAE INTERNATIONAL

**SURFACE VEHICLE RECOMMENDED PRACTICE**

J30XX

PropDft JAN2013

Issued xxxx-xx
Revised xxxx-xx
Reaffirmed xxxx-xx
Superseded xxxx-xx
Cancelled xxxx-xx

Superseding JxxxxxDate

Ambulance Modular Body Evaluation-Quasi-Static loading For Type I and Type III Modular Ambulance Bodies

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the ambulance modular body for Type I and Type III bodies. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded and managed by the National Institute for Occupational Safety and Health, the Department of Homeland Security and the Ambulance Manufacturers Division of the NTEA. Input loading for the dynamic testing was generated using the test methodology described in ECE R66. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community.

1. SCOPE

This SAE Recommended Practice describes the test procedures to be used to evaluate the strength of a modular ambulance body roof and side wall. This test methodology includes a dynamic and two quasi-static tests performed in combination. . Its purpose is to establish repeatable test methodology which will be adopted as standardized test procedures for Type I, Type I-AD, Type III or Type III-AD bodies. This Recommended Practice provides ambulance builders and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent, ensure the ambulance structure meets the same performance criteria across the industry. Descriptions of the test set-up, test instrumentation, photographic/video coverage, and the test fixtures are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

SAE J211-2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation



Key Elements in 3 Phase Recommended Practice

- Phase 1 is a dynamic test where patient compartment is impacted by large mass
- Phases 2 & 3 are both quasi-static tests evaluate roof and side wall strength
- Doors must open after each test with a minimal 66 lb. force applied

# Roll Test Provides Impact Loading on Roof Edge

Utilized an Accepted Roll Test, ECE R66 to Collect Impact Load Data

Impacted Surface Measures Loads Using Force Plates – Much Like a Large Scale

# Phase 1: Dynamic Impact Simulates Roll Impact

28,000 lb. force derived from actual ambulance roll test

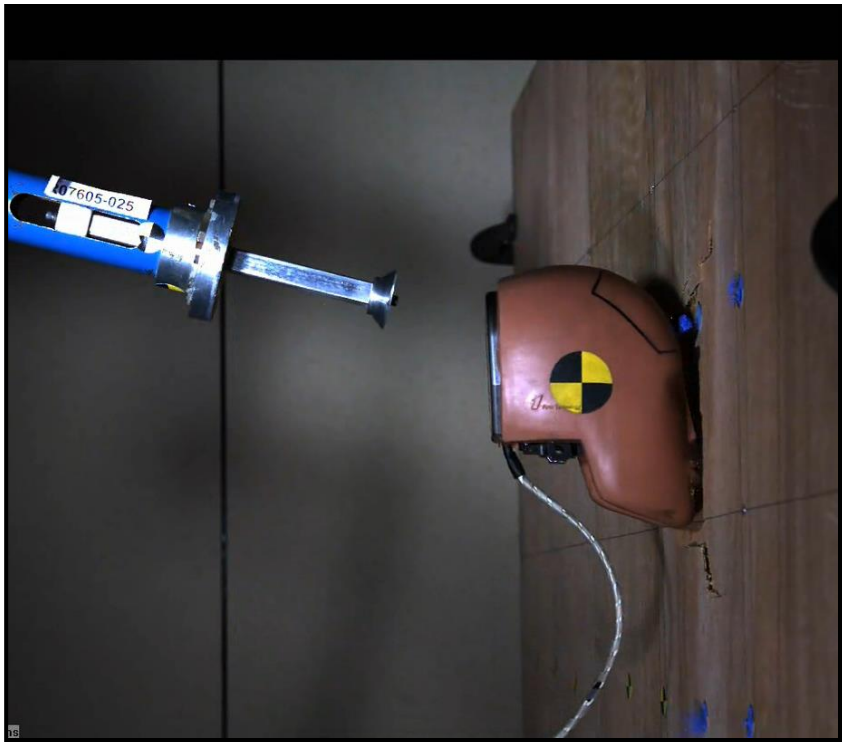
# Phases 2 and 3: Quasi-Static Load on Roof and Side



Applied Load Equals 2.5 times GVWR first on roof then vehicle rolled on side and load applied again all using the same previously impacted modular body

# Designing Safer Head Impact Regions

Ram and Instrumented Head Allow Engineers to Test Surfaces and Surface Treatments to Reduce Head Injury



# Ongoing Research to Improve EMS Worker Safety

- EMS Worker Anthropometry Study – Assessing body sizes and shapes (640 human subjects to be measured – 480 complete)

- Development of a prototype ambulance based on this work plus companion research at NIST and DHS addressing patient compartment layout

- Production of an informational DVD to be provided to all EMS services nationwide

# What can you do to encourage worker safety?

- Adopt the new safety test methods and standards as they are published
- Make it a priority to replace the patient cot/litter with each new ambulance purchase
- Strongly encourage the use of safety belts in the patient compartment in new and in older vehicles
- Strongly encourage employees to use shoulder restraints on the patient
- Stow or lock down medical equipment & supplies

# Contact Information

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**Disclaimer:** ***The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH).***

# GSA Motor Vehicle Management Resources

- GSA Fleet Drive-thru and Training
- Consolidate Your Vehicles With GSA Fleet
- Short Term Rental Program
- Dispatch Reservation Module
- Federal Fleet Management System (FedFMS)
- Car Sharing
- Alternative Fuel Vehicle Guide
- WEX Station Locator / DOE Station Locator
- 2015 FFMT Presentations